

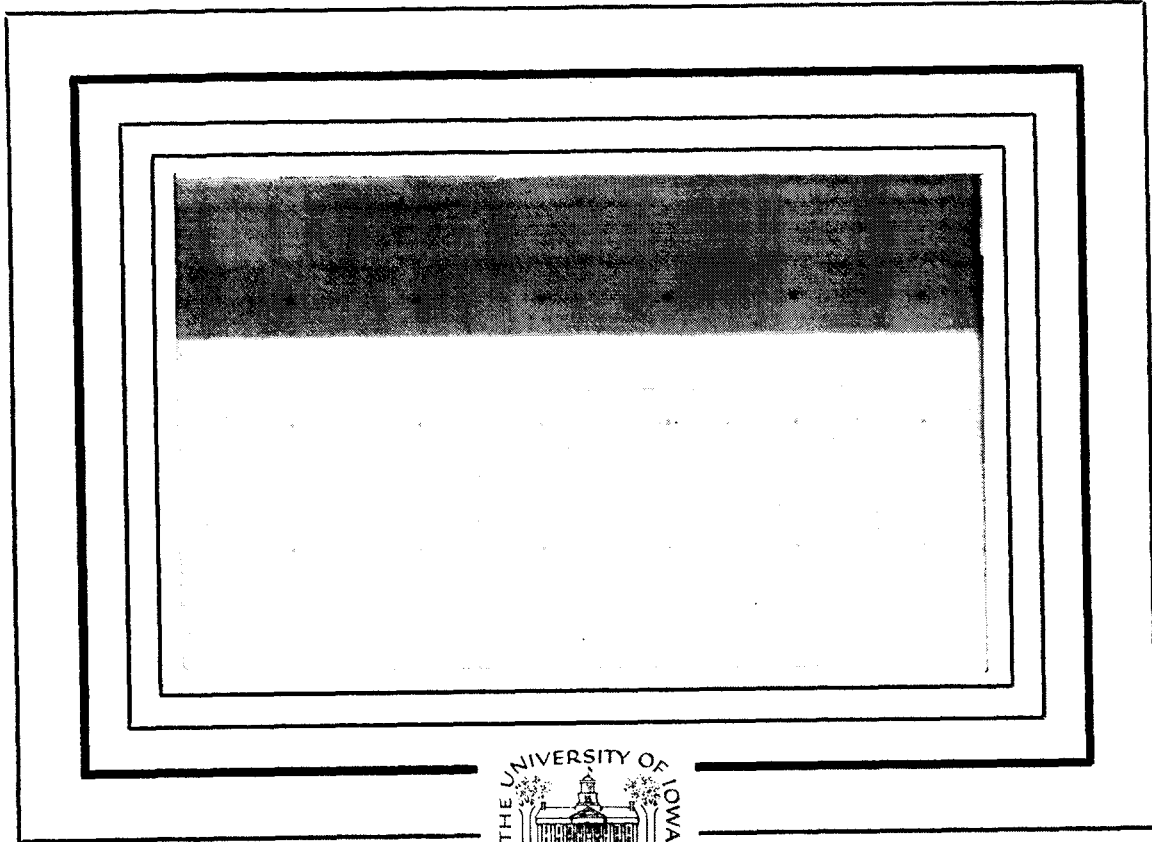
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PLASMA PHYSICS ABSTRACTS

1 January 1986 through 31 December 1986

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by

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This collection of abstracts represents the plasma physics publications from the Department of Physics and Astronomy at the University of Iowa which are considered relevant to NASA Grant NGL-16-001-043. In some cases other grants and contracts have been used for partial support. This support is acknowledged in the individual papers.

The last such collection was issued on 11 March 1986. The papers are numbered consecutively beginning with the published works, then followed by papers which have been accepted or submitted for publication.

1. Laboratory Observations of Ion-Cyclotron Waves Associated With a Double Layer in an Inhomogeneous Magnetic Field
M. J. ALPORT, S. L. CARTIER and R. L. MERLINO
J. Geophys. Res., 91, 1599, 1986.

Observations of coherent electrostatic ion-cyclotron (EIC) waves associated with a strong, magnetized double layer are presented. The double layers are produced in a weakly ionized argon plasma by applying a positive potential to an electrode plate located in a diverging, solenoidal magnetic field region of a cylindrical plasma column. Ionization within the electrode sheath is essential to the formation of these double layers. The resulting V-shaped potential structures have extended parallel, oblique and perpendicular (to **B**) electric field components. The frequency of the ion-cyclotron instability is dependent upon the position of the magnetic field-aligned potential structure. The properties of EIC waves in the presence of double layer are discussed in relation to the possible excitation mechanisms (field-aligned currents, ion and electron beams, and perpendicular **E** fields).

2. Plasma Waves Observed by the IRM and UKS Spacecraft During the AMPTE Solar Wind Lithium Releases: Overview
B. HAEUSLER, L. J. WOOLISCHROFT, R. R. ANDERSON, D. A. GURNETT, R. H. HOLZWORTH, H. C. KOONS, O. H. BAUER, G. HAERENDEL, R. A. TREUMANN, P. J. CHRISTIANSEN, A. G. DARBYSHIRE, M. P. GOUGH, S. R. JONES, A. J. NORRIS, H. LUEHER and H. KLOCKER
J. Geophysical Res., 91, 1283, 1986.

The two September 1984 solar wind lithium releases produced a rich variety of plasma waves which have been measured in situ by the plasma wave instrumentation on board the AMPTE/IRM and UKS spacecraft. Reflection of the natural galactic and terrestrial electromagnetic radiation from the dense Li-plasma caused a cutoff in the high-frequency electric field intensities from which the temporal and spatial variation of the plasma density can be determined. Inside the diamagnetic cavity the electron plasma frequency and temporarily also the Li-plasma frequency have been excited. The emission at the electron plasma frequency is near the thermal fluctuation level. In addition weak low frequency ion-acoustic waves were observed. The boundary between the diamagnetic cavity and the external magnetic field was found to be surprisingly stable and contained extremely low levels of wave activity. In the transition region from the diamagnetic cavity to the solar wind, high wave activity at the medium and very low frequencies propagating mainly in the ion-acoustic and electrostatic cyclotron harmonic modes was encountered. No wave magnetic fields were detected in this region. The upstream edge of the transition region was characterized by a steep decay in magnetic field strength, density, and by a sudden increase in the quasi-static electric field. At this time

the ELF/MF rms wave amplitude explosively increased to a value of 50 mV/m and remained at an enhanced level for more than 1 min. The spectrum of this wave activity is similar to the electrostatic noise observed in collisionless shocks. Data from the UKS indicate that during the releases UKS was in the magnetic transition zone. The wave activity at UKS was distinctly different from that encountered by the IRM. The intense emission at the electrostatic shock-like transition was weaker than on the IRM and for the second release appeared at a different time. This can be related to the different positions of the two spacecraft with respect to the interaction regions. Despite the high wave intensities, the estimated wave energy densities are, however, too low by orders of magnitude to drive significant magnetic field diffusion during the in situ observation times. Some differences in the wave excitations for the two releases can be traced back to the different solar wind conditions.

3. Analysis and Interpretation of the Shock-Like Electrostatic Noise Observed During the AMPTE Solar Wind Lithium Releases
D. A. GURNETT, T. Z. MA, R. R. ANDERSON, O. H. BAUER, G. HAERENDEL, B. HAUESLER, G. PASCHMANN, R. A. TREUMANN, H. C. KOONS, R. HOLZWORTH and H. LUEHR
J. Geophys. Res., 91, 1301, 1986.

During the AMPTE (Active Magnetospheric Particle Tracer Explorers) solar wind lithium release on September 11, and again on September 20, 1984, an intense burst of electrostatic noise was observed near the upstream edge of the ion cloud. Comparisons with measurements by the IMP-6 and ISEE-1 spacecraft show that the spectrum and overall features of this noise are very similar to electrostatic noise observed at the earth's bow shock. A stability analysis using realistic parameters shows that the electrostatic noise can be accounted for by an ion beam-plasma instability caused by the solar wind proton beam streaming through the nearly stationary lithium cloud. The growth rate of this instability is largest when the ion density and solar wind proton density are similar, which explains why the noise only occurs near the outer edge of the ion cloud.

The similarity to the noise in the earth's bow shock suggests that a shock may exist in the solar wind plasma flow upstream of the ion cloud. If the noise is associated with a shock, then it must be an electrostatic shock, since the ion cyclotron radii are too small for the existence of a MHD shock. Since the electrostatic instability occurs at phase velocities near the lithium thermal velocity, the electrostatic turbulence may play a role in heating the lithium ions and transferring momentum from the solar wind to the ion cloud. The noise may also play a role in the pitch-angle scattering and diffusion of energetic electrons observed in the vicinity of the ion cloud. Because of the similarity to the solar wind interaction with the gaseous envelope of a comet, it is expected that similar types of wave-particle effects may occur upstream of comets.

4. Whistler-Mode Radiation From the Spacelab 2 Electron Beam
D. A. GURNETT, W. S. KURTH, J. T. STEINBERG, P. M. BANKS, R. I. BUSH and W. J. RAITT
Geophys. Res. Lett., 13, 225-228, 1986.

During the Spacelab 2 mission the Plasma Diagnostics Package (PDP) performed a fly-around of the shuttle at distances of up to 300 meters while an electron beam was being ejected from the shuttle. We discuss a magnetic conjunction of the shuttle and the PDP while the electron gun was operating in a steady (DC) mode. During this conjunction, the PDP detected a clear funnel-shaped emission that is believed to be caused by whistler-mode emission from the beam. Ray-path calculations show that the shape of the funnel can be accounted for by whistler-mode waves propagating near the resonance cone. Because the beam and waves are propagating in the same direction, the radiation must be produced by a Landau, $\omega/k_{\parallel} = v_b$, interaction with the beam. Other types of waves generated by the beam are also described.

5. Dust Particles Detected Near Giacobini-Zinner by the Ice Plasma Wave Instrument
D. A. GURNETT, T. F. AVERKAMP, F. L. SCARF AND E. GRUN
Geophys. Res. Lett., 13, 291-294, 1986.

During the ICE flyby of Giacobini-Zinner the plasma wave instrument detected numerous impulsive signals caused by dust impacts on the spacecraft. Most of the impacts occurred within 30,000 km of the comet. The impact rate averaged over the inbound and outbound legs varies approximately as $1/r^2$, as would be expected for an isotropic constant velocity radial outflow. Small differences between the inbound and outbound legs exist which may be indicative of azimuthal variations in the dust production rate. A simple model of the impact ionization and charge collection by the antenna indicates that the particles have a mass on the order of 10^{-12} to 10^{-10} gm, corresponding to particles with radii of a few microns.

6. New Waves at Multiples of the Plasma Frequency Upstream of the Earth's Bow Shock
IVER CAIRNS
J. Geophys. Res., 91, 2975-2988, 1986.

The first observations of waves at harmonics higher than the second of the electron plasma frequency are reported. The observations were made by the ISEE-1 spacecraft upstream of the Earth's bow shock. The waves are interpreted as electromagnetic radiation at the fundamental and up to the fifth harmonic of the plasma frequency, with effective temperatures decreasing from 5×10^{17} K to 10^8 K over this range. Two models for the emission of the waves are sketched.

7. Dispersive Ducting of MHD Waves in the Plasma Sheet: A Source of Pi2 Wave Bursts

P. M. EDWIN, B. ROBERTS and W. J. HUGHES

Geophys. Res. Lett., 13, 373-376, 1986.

Fast magnetoacoustic waves can be ducted by plasma inhomogeneities such as the plasma sheet. As this ducting is dispersive an impulsive source will give rise to a well-defined, quasi-periodic wave packet with time-scales determined by the width of the inhomogeneity and characteristic speeds in the wave duct and surrounding medium. The duration of the wave packet depends upon the distance from the source. We argue that an impulsive source in the plasma sheet at substorm onset will produce a wave packet near earth with characteristics similar to pi2 wave bursts and put this idea forward as a mechanism for the generation of pi2 pulsations.

8. AKR Signal Increases Caused by Triggering

W. M. FARRELL, W. CALVERT and D. A. GURNETT

Geophys. Res. Lett., 13, 370-372, 1986.

This paper presents a study of the amplitude increases which accompany the triggering of auroral kilometric radiation (AKR) by Type-III solar radio bursts. IMP-8 data were used to determine the signal increases observed during one-hour periods before and after Type-III bursts at 100 kHz, 178 kHz and 500 kHz and these were compared with similar observations when the Type-III bursts were absent. The results indicate that between 8 to 16% of the Type-III bursts caused statistically significant intensity increases and that infrequent large signal increases of sometimes 20 dB or more tended to characterize the triggered AKR, rather than a large proportion of small increases.

9. On the Time Interval Between Successive Lightning Flashes

N. D'ANGELO

Ann. Geophys., 4, 343, 1986.

A suggestion by Pathak et al. (1980), that the electrochemical charge separation mechanism in thunderclouds is capable of accounting for interflash time intervals of 10 s or less, is examined on the basis of a recent model by the author. Agreement is found with Pathak's suggestion.

10. A Laboratory Study of Ion Energization by EIC Waves and Subsequent Upstreaming Along Diverging Magnetic Field Lines

S. L. CARTIER, N. D'ANGELO and R. L. MERLINO

J. Geophys. Res., 91, 8025, 1986.

A laboratory study related to energetic upstreaming ions in the ionosphere-magnetosphere system is described. The experiment was

carried out in a cesium Q-machine plasma with a region of nonuniform magnetic field. Electrostatic ion-cyclotron waves were excited by drawing an electron current to a small biased exciter electrode. In the presence of the instability, ions are heated in the direction perpendicular to \underline{B} . Using a gridded retarding potential ion-energy analyzer, we followed the evolution of the ion velocity distribution as the ions passed through the heating region and subsequently flowed out along the diverging \underline{B} -field lines. As expected, the heated ions transfer their energy from perpendicular to parallel motion as they move through the region of diverging \underline{B} field. Both their parallel thermal energy and the parallel drift energy increase at the expense of the perpendicular energy.

11. Laboratory Observations of Ion-Cyclotron Waves Associated With a Double Layer in an Inhomogeneous Magnetic Field
M. L. ALPORT, S. L. CARTIER and R. L. MERLINO
J. Geophys. Res., 91, 1599, 1986.

Observations of coherent electrostatic ion-cyclotron (EIC) waves associated with a strong, magnetized double layer are present. The double layers are produced in a weakly ionized argon plasma by applying a positive potential to an electrode plate located in a diverging, solenoidal magnetic field region of a cylindrical plasma column. Ionization within the electrode sheath is essential to the formation of these double layers. The resulting V-shaped potential structures have extended parallel, oblique and perpendicular (to \underline{B}) electric field components. The frequency of the ion-cyclotron instability is dependent upon the position of the magnetic field-aligned potential structure. The properties of EIC waves in the presence of double layer are discussed in relation to the possible excitation mechanisms (field-aligned currents, ion and electron beams, and perpendicular \underline{E} fields).

12. Magnetohydrodynamic Solitons and Radio Knots in Jets
R. FIEDLER
Ap. J., 305, 100, 1986.

Weakly nonlinear surface waves are examined in the context of the beam model for jetlike radio sources. By introducing a finite scale length, via the beam radius, geometrical dispersion can act to balance nonlinear wave growth and thereby produce solitons, localized wave packets of stable waveform. A method for obtaining a soliton equation from the MHD equations is presented and then applied to radio knots in jets.

13. First Plasma Wave Observations at Uranus
D. A. GURNETT, W. S. KURTH, F. L. SCARF and R. L. POYNTER
Science, 233, 106, 1986.

Radio emissions from Uranus were detected by the Voyager 2 plasma wave instrument about 5 days before closest approach at frequencies of 31.1 and 56.2 kHz. The bow shock was identified by an abrupt broadband burst of electrostatic turbulence about 10 hours before closest approach at a radial distance of $23.5 R_U$. Once inside of the magnetosphere strong whistler-mode hiss and chorus emissions were observed at radial distances less than about $8 R_U$, in the same region where the energetic particle instruments detected intense fluxes of energetic electrons. A variety of other plasma waves, such as $3f_c/2$ electron cyclotron waves, were also observed in this same region. At the ring plane crossing the plasma wave instrument detected a large number of impulsive events that are interpreted as impacts of micron-sized dust particles on the spacecraft. The maximum impact rate was about 20 to 30 impacts/sec, and the north-south thickness of the impact region was about 4,000 km.

14. Plasma Waves Associated With the First AMPTE Magnetotail Barium Release
D. A. GURNETT, R. R. ANDERSON, P. A. BERNHARDT, H. LUEHR, G. HAERENDEL, O. H. BAUER, H. C. KOONS and R. H. HOLZWORTH
Geophys. Res. Lett., 13, 644, 1986.

Plasma waves observed during the March 21, 1985, AMPTE magnetotail barium release are described. Electron plasma oscillations provided local measurements of the plasma density during both the expansion and decay phases. Immediately after the explosion the electron density reached a peak of about $4 \times 10^5 \text{ cm}^{-3}$, and then started decreasing approximately as $t^{-2.4}$ as the cloud expanded. About 6 minutes after the explosion the electron density suddenly began to increase, reached a secondary peak of about $2.4 \times 10^2 \text{ cm}^{-3}$, and then slowly decayed down to the pre-event level over a period of about 15 minutes. The density increase is believed to be caused by the collapse of the ion cloud into the diamagnetic cavity created by the initial expansion. The plasma wave intensities observed during the entire event were quite low. In the diamagnetic cavity electrostatic emissions were observed near the barium ion plasma frequency, and in another band at lower frequencies. A broadband burst of electrostatic noise was also observed at the boundary of the diamagnetic cavity. Except for electron plasma oscillations no significant wave activity was observed outside of the diamagnetic cavity.

15. Magnetic Field Corrections to Solar Oscillation Frequencies
B. ROBERTS and W. R. CAMPBELL
Nature, 323, 603, 1986.

The presence of magnetic field both deep within the Sun and in its atmosphere raises the question of the field's influence on the p- and g-modes of oscillation and the implications for helioseismology. Observations^{1,2} of p-modes, in particular, have permitted a theoretical determination³ of the run of sound speed within the solar interior, thus providing a seismological probe of the Sun's depths. Magnetic fields within the Sun are likely to be too weak to significantly affect this determination of the sound speed. Nonetheless, magnetic fields may modify the oscillation frequencies in a distinctive fashion, thereby raising the possibility of placing limits on interior field strengths through frequency measurements.⁴ Recently, Woodard and Noyes⁵ have reported a slight but systematic decrease in frequencies of low degree p-modes from 1980 to 1984. Here we argue that the frequencies of both p- and g-modes are modified by a magnetic field. In particular, we attribute the decrease in p-mode frequencies to a magnetic field within the solar interior evolving over the solar cycle. Field strengths at the base of the convection zone of at least 5×10^5 G are required.

16. Waves and Electric Fields Associated With the First AMPTE Artificial Comet
D. A. GURNETT, T. Z. MA, R. R. ANDERSON, G. HAERENDEL, G. PASCHMANN, O. H. BAUER, R. A. TREUMANN, H. C. KOONS, R. HOLZWORTH and H. LUEHR
J. Geophys. Res., 91, 10,013, 1986.

A variety of plasma wave and electric field effects were observed during the AMPTE (Active Magnetospheric Particle Tracer Explorers) solar wind barium release on December 27, 1984. Electron plasma oscillations at the local electron plasma frequency provided measurements of the electron density during the entire event. Inside the diamagnetic cavity created by the ion cloud, the electron density reached a peak of about $2 \times 10^5 \text{ cm}^{-3}$, then decreased approximately as t^{-2} as the cloud expanded. A static electric field of about 1 to 2 mV/m was detected in the diamagnetic cavity. This electric field is in the same direction as the solar wind electric field, suggesting that polarization charges in the ion cloud are not effective at shielding out an external electric field. As the spacecraft passed through the boundary of the diamagnetic cavity, a region of compressed plasma and magnetic field was detected upstream of the ion cloud with a peak density of about 10^4 cm^{-3} and magnetic field strength of 130 nT. This region of compressed plasma is believed to be caused by solar wind plasma and magnetic field lines draped around the nose of the ion cloud. Inside the diamagnetic cavity electrostatic emissions were observed in a narrow band centered on the barium ion plasma frequency and in another

band at lower frequencies. These waves are believed to be short wavelength ion acoustic waves. Bursts of electrostatic waves were also observed at the boundaries of the diamagnetic cavity, apparently caused by an electron drift current along the boundary. Near the outer boundary of the plasma compression region, an intense burst of broadband electrostatic noise was observed with intensities of up to 140 mVolts/m. This noise is apparently associated with a shock-like interaction between the ion cloud and the solar wind. Growth rate computations show that this noise can be accounted for by an electrostatic ion beam-plasma interaction between the nearly stationary barium ions and the rapidly moving solar wind protons.

17. The Conductance of Auroral Magnetic Field Lines

D. R. WEIMER, D. A. GURNETT and C. K. GOERTZ

Ion Acceleration in the Magnetosphere and Ionosphere, Geophysical Monograph 38, p. 108, 1986.

Recent results from the Dynamics Explorer satellites have indicated that in the auroral zone a linear relationship exists between the field-aligned current density and the potential drop parallel to the magnetic field lines. Evidence for this "Ohm's law" relationship was found in the mapping of perpendicular electric fields and field-aligned currents between high and low altitudes. The mapping depends on the perpendicular wavelength of the electric field variations. A scale length in the mapping formula is determined by the ratio of the parallel field line conductance and the ionospheric Pedersen conductance. The wavelength and the conductivity ratio also control the relationship between the perpendicular electric and magnetic fields at high altitudes.

We show here that at the short-wavelength limit the ionospheric conductivity is no longer important in the relationship between the north-south electric field and the east-west magnetic field at high altitudes (i.e., above the parallel potential drop). At the short-wavelength limit the relationship takes on a simple form. The integral of the perpendicular electric field results in a potential profile which, according to the linear theory, is proportional to the current density. Assuming that the currents are in the form of "infinite shears" orientated east-west, the second integral of the electric field is proportional to the magnetic field.

High-time resolution data from the DE-1 satellite are shown here for two events with very large electric fields which reversed directions within a short distance. The results agree very well with the linear theory. The field line conductance is determined to be of the order of 10^{-9} mho/m². The same conductance appears to be valid for both upward and downward currents. Ions are accelerated from the ionosphere to magnetosphere by the potential drops in regions of upward current.

18. Evidence for Parametric Decay of Langmuir Waves in Solar Type III Radio Bursts

R. P. LIN, W. LOTKO, D. A. GURNETT and F. L. SCARF

Ap. J., 308, 954, 1986.

We present evidence for the parametric decay of Langmuir waves in the solar wind into transverse electromagnetic waves and ion acoustic waves. The Langmuir waves are driven by electron beams associated with Type-III solar radio bursts in the interplanetary medium. Ion acoustic waves with wave number approximately equal to the beam resonant Langmuir wave number are observed coincident in time with the most intense spikes of the Langmuir waves. This decay process may provide the Type-III radio emission near the plasma frequency.

19. Transverse Auroral Ion Energization Observed on DE-1 With Simultaneous Plasma Wave and Ion Composition Measurements

W. K. PETERSON, E. G. SHELLEY, S. A. BOARDSEN and D. A. GURNETT
Ion Acceleration in the Magnetosphere and Ionosphere, Geophysical Monograph 38, p. 43, 1986.

The abundance of oxygen ions observed flowing into the magnetosphere can not be explained by a single step, parallel acceleration mechanism. Some transverse energization of ionospheric ions is required and has been observed from ionospheric altitudes to the plasma lobes in the earth's magnetotail. Progress in understanding the nature of the various transverse energization mechanisms has been slow because of the relative lack of examples with sufficiently resolved (in time, energy, and frequency) particle and wave data. Starting in early 1984 the Dynamics Explorer-1 systematically acquired a coordinated set of high time resolution plasma and plasma wave observations from the earth's auroral zone. We have selected several intervals from the 0 to 10 kHz, wideband data from the Dynamics Explorer-1 satellite with intense low frequency emissions with evidence of harmonic structure and have examined in detail the high resolution ion data obtained simultaneously. In this report we present detailed data from events in the cusp and evening auroral zone and comment briefly on how these data can be used to more fully understand auroral acceleration processes.

20. DE 1 Observations of Harmonic Auroral Kilometric Radiation

M. M. MELLOTT, R. L. HUFF and D. A. GURNETT

J. Geophys. Res., 91, 13,732, 1986.

The plasma wave instrument onboard the DE-1 spacecraft has observed several intervals of auroral kilometric radiation (AKR) during which harmonic structure is clearly present. Evidence, some of which is based on unique capabilities of the DE instrument, is presented which argues strongly that the harmonic structures are natural rather than instrumental in origin. The harmonic emissions occur infrequently, but when present may persist for intervals of up to an hour. The

emissions are relatively narrow band, and consist of a relatively weak fundamental (10^{-14} - 10^{-11} V²/m²-Hz) accompanied by an even weaker second harmonic. The ratio of power in the fundamental band to the power in the harmonic ranges from 10 to 100. In all cases, polarization data indicates that the fundamental is a left-hand ordinary (L-O) mode emission while the harmonic is a right-hand extraordinary (R-X) mode. These observations are consistent with predictions based on the cyclotron maser mechanism.

21. Electron Plasma Waves in the Solar Wind: AMPTE/IRM and UKS Observations
 R. A. TREUMANN, O. H. BAUER, J. LABELLE, G. HAERENDEL, P. J. CHRISTIANSEN, A. G. DARBYSHIRE, A. J. NORRIS, L. J. C. WOOLLISCROFT,
 R. R. ANDERSON, D. A. GURENTT, R. W. HOLZWORTH, H. C. KOONS and J. ROEDER
Adv. in Space Res., 6, 93, 1986.

Selected events of plasma wave and electromagnetic emissions in the earth's electron fore-shock region have been studied. Strong emissions are observed in the plasma-wave band when the site of the satellite is magnetically connected to the bow shock. These emissions are generally highly fluctuating. Under certain conditions one observes electromagnetic radiation at the second harmonic produced locally. Electromagnetic emission generated at a position far away from the site of the spacecraft is occasionally detected giving rise to remote sensing of the bow shock. These emissions are related to energetic electron fluxes.

22. Satellite Interferometric Measurements of Auroral Kilometric Radiation
 M. M. BAUMBACK, D. A. GURNETT, W. CALVERT and S. D. SHAWHAN
Geophys. Res. Lett., 13, 1105, 1986.

The first satellite interferometric measurements of auroral kilometric radiation (AKR) were performed by cross-correlating the waveforms detected by the ISEE 1 and ISEE 2 spacecraft. Such correlations were measured at 125 and 250 kHz for projected baselines ranging from 20 to 3868 km. High correlations are found at all projected baselines, with little or no tendency to decrease at long baselines. These results are interpreted differently for incoherent and coherent radiation. For incoherent radiation, the correlation as a function of the baseline is the Fourier transform of the source brightness distribution, and this would imply an average source region diameter for all the bursts analyzed of less than about 10 km. For such small source diameters, the required growth rates are too large to be explained by existing incoherent theories, strongly indicating that the radiation must be coherent. For coherent radiation, an upper limit to the source

region diameter can be inferred instead from the angular width of the radiation pattern. The close similarity of the spectra at the longest baselines indicates that the angular width of the radiation pattern must be at least 2.5 degrees, implying that the diameter of the source must be less than 20 km. At present, the proposed closed-loop radio lasting model provides the only known mechanism for generating sources this small.

23. A Laboratory Study of Collisional Electrostatic Ion-Cyclotron Waves

D. M. SUSZCYNISKY, S. L. CARTIER, R. L. MERLINO and N. D'ANGELO
J. Geophys. Res., 91, 13,729, 1986.

The effects of neutral-particle collisions on current-driven electrostatic ion cyclotron (EIC) waves are studied in a Q machine with a Cesium (Cs^+) plasma. We find that even when $v_{in} \approx 0.3 \omega_{ci}$, EIC waves of substantial amplitude ($\Delta n/n$ of several percent) can be excited.

24. Current-Voltage Relationship in Auroral Current Sheets

D. R. WEIMER, D. A. GURNETT, C. K. GOERTZ, J. D. MENIETTI, J. L. BURCH and M. SUGIURA
J. Geophys. Res., in press, 1986.

The current-voltage relation within narrow auroral current sheets is examined through the use of high-resolution data from the high altitude Dynamics Explorer 1 satellite. The north-south perpendicular electric field and the east-west magnetic field are shown for three cases in which there are large amplitude, oppositely directed paired electric fields and narrow current sheets. These data are shown to indicate that there is a linear "Ohm's law" relationship between the current density and the parallel potential drop within the narrow current sheets. This linear relationship had previously been verified for large-scale auroral formations greater than 20 km wide at the ionosphere. The evidence shown here extends our knowledge down to the scale size of discrete auroral arcs.

25. Guided MHD Waves as a Coronal Diagnostic Tool

B. ROBERTS
Proceedings, Solar Maximum Mission Workshop on 'Coronal and Prominence Plasmas,' ed. by A. I. Poland, NASA, in press, 1986.

The coronal atmosphere is observed to be highly inhomogeneous with marked density and temperature variations; coronal loops abound. Magnetic forces dominate the atmosphere providing thermal insulation across field lines and almost rigid wave guides for the propagation of MHD waves. In a homogeneous low beta plasma, the slow magnetoacoustic

wave gives one-dimensional propagation of sound whereas the fast magnetoacoustic wave gives isotropic propagation at the Alfvén speed. (See Weitzner (1983) and Roberts (1984, 1985) for recent discussions of the properties of MHD waves.) If, however, the low beta plasma is inhomogeneous in density, as with the corona, then fast magnetoacoustic waves are guided by regions of low Alfvén speed (Habbal, Leer, Leer, and Holzer 1979; Edwin and Roberts 1982, 1983; Roberts, Edwin, and Benz 1983, 1984; see also Newcomb 1957). For a general overview see Edwin and Roberts (1986a). Regions of low Alfvén speed occur in both coronal loops and in open field regions (coronal holes). We note, too, that current sheets (regions of the plasma where field reversal occurs) provide wave guides for fast magnetoacoustic waves (Edwin, Roberts, and Hughes 1986).

An important thing about such wave guides is that they preferentially select certain ranges of frequency and wavenumber for guided propagation. If a fast mode is generated impulsively, such as by a flare, it is guided along a region of low Alfvén speed and will exhibit frequencies of the order of the Alfvén speed divided by the width of the inhomogeneity. For typical coronal conditions, this will give rise to frequencies of about 1 Hz or higher. An important thing about such wave guides is that they preferentially select certain ranges of frequency and wavenumber for guided propagation. If a fast mode is generated impulsively, such as by a flare, it is guided along a region of low Alfvén speed and will exhibit frequencies of the order of the Alfvén speed divided by the width of the inhomogeneity. For typical coronal conditions, this will give rise to frequencies of about 1 Hz or higher.

The occurrence of preferred frequencies in an impulsively generated fast magnetoacoustic wave raises the interesting possibility that such distinctive signatures could be used as a seismological probe of the coronal atmosphere, allowing us to determine magnetic field strengths and/or spatial extents of density inhomogeneities. We discuss this possibility here (see also Edwin and Roberts 1986b).

26. Jovian Magnetospheric Processes

C. K. GOERTZ

Proceedings of the Magnetospheric Phenomena in Astrophysics Workshop, Taos, New Mexico, August 1984, in press.

Jupiter's rotational energy (6×10^{34} J) powers a large number of processes such as auroral UV emission, radio waves, and charged particle energization. We describe how the rotational energy may be dissipated by injection of plasma, magnetic pumping and field aligned electric fields. In addition, we describe energization by radial diffusion and plasma wave absorption. We also describe the generation of Alfvén waves by the moon Io and their relation to the emission of the Jovian DAM radio waves.

27. An Analysis of the Shock-Like Electrostatic Noise Observed During AMPTE Solar Wind Ion Releases

T. Z. MA, D. A. GURNETT and N. OMIDI
J. Geophys. Res., in press, 1986.

For the purpose of explaining the shock-like noise detected by the IRM (Ion Release Module) instruments during the AMPTE (Active Magnetospheric Particle Tracer Explorers) solar wind ion releases, we present an analysis of electrostatic waves produced by the interaction of the ion cloud with the solar wind. This analysis considers an arbitrary direction of propagation. It is found that in the absence of cold photoelectrons the maximum growth rate occurs almost perpendicular to the solar wind velocity. The wave growth is much higher than for propagation parallel to the solar wind direction, and is caused by an ion-ion interaction between the injected ions (Ba^+ or Li^+) and the solar wind protons. However, in the presence of cold photoelectrons, the growth rate for the ion-ion interaction is comparable or less than for parallel propagation, which is primarily an ion-electron interaction. Therefore, both types of interactions are probably involved in generating the shock-like electrostatic noise. The ion-ion instability is more likely to occur in the later stage of the cloud expansion after the cold photoelectrons have escaped and the ion-electron instability is more likely, or at least comparable to the ion-ion instability, in the early stages when the photoelectrons are dominant.

28. The Minimum Bandwidths of Auroral Kilometric Radiation

M. M. BAUMBACK and W. CALVERT
Geophys. Res. Lett., in press, 1986.

The bandwidths of the discrete spectral components of the auroral kilometric radiation can sometimes be as narrow as 5 Hz. Since this would imply an apparent source thickness of substantially less than the wavelength, it is inconsistent with the previous explanation for such discrete components based simply upon vertical localization of a cyclotron source. Instead, such narrow bandwidths can only be explained by radio lasing.

29. Planetary Radio Waves

C. K. GOERTZ
Proceedings of the Magnetospheric Phenomena in Astrophysics Workshop, Taos, New Mexico, August 1984, in press.

Three planets, the earth, Jupiter and Saturn are known to emit non-thermal radio waves which require coherent radiation processes. The characteristic features (frequency spectrum, polarization, occurrence probability, radiation pattern) are discussed. We distinguish between radiation which is externally controlled by the solar wind and internally controlled radiation which only originates from Jupiter.

The efficiency of the externally controlled radiation is roughly the same at all three planets (5×10^{-6}) suggesting that similar processes are active there. We discuss briefly the maser radiation mechanism for the generation of the radio waves and general requirements for the mechanism which couples the power generator to the region where the radio waves are generated.

30. Dynamical Processes in Magnetic Flux Tubes

B. ROBERTS

Abhandlungen der Akademien der Wissenschaften, Göttingen Academy of Sciences, Göttingen, in press.

The concept of an isolated flux tube has proved to be extremely fruitful as a means of investigating the theoretical behavior of concentrated magnetic field in the solar photosphere. By considering the extreme of a slender (or thin) flux tube it is possible to investigate the dynamical behavior of the tube, accounting for a variety of physical effects including stratification and compressibility.

31. Electron Acceleration via Kinetic Alfvén Waves

C. K. GOERTZ

Proceedings, International Conference on Comparative Study of Magnetospheric Systems, La Londe-les-Maures, France, in press.

Obliquely propagating shear Alfvén waves are effected by kinetic effects. The wave becomes dispersive and carries a significant parallel electric field when $k_{\perp} R_g \gtrsim 1$ or $k_{\perp} c/\omega_{pe} \gtrsim 1$. We discuss the polarization and dispersion of these waves and show that electrons can be effectively accelerated along field lines by these waves. We also discuss several nonlinear effects such as solitary waves, nonlinear damping due to current-driven instabilities, and anomalous resistivity. Finally, we describe recent observations of electric and magnetic field perturbations on auroral field lines which seem to be related to these waves. However, the evidence for the existence of these kinetic Alfvén waves is not firm.

32. On X-Rays From Thunderclouds and Lightning Discharges

N. D'ANGELO

Ann. Geophys., submitted, 1986.

The question of x-ray generation in thunderclouds and lightning discharges is examined. Energetic electrons ($> \sim 100$ keV) may be produced by the large ($\sim 10^7$ V/m) electric fields of return strokes and, in turn, give rise to Bremsstrahlung x-rays. Estimates of the x-ray fluxes are presented.

33. Conditions Conducive to the Existence of a Double Layer
 GEORG KNORR, ROBERT L. MERLINO, and MICHAEL ALPORT
Phys. Fluids, submitted.

Stationary, one-dimensional double layers are constructed analytically by using distribution functions which are constant for the four particle species, namely trapped and free ions and electrons. General conditions for the existence of double layers are derived for this case, and several special cases are discussed. For example, we find it conducive for the existence of double layers if distribution functions are concentrated close to the bifurcation trajectory which separates trapped and free particle phase space. Strong double layers can exist, if the "temperatures" of all four particle species are small compared with the potential difference of the double layer. Double layers are facilitated by the existence of trapped ions and electrons; they can also exist with only one trapped species. No double layers can exist without trapped particles. Double layer solutions can also be found if electrons have a Boltzmann density distribution.

34. Physics of the Inner Heliosphere: Waves and Discontinuities
 K. U. DENSKAT and D. A. GURNETT
Physics of the Inner Heliosphere, submitted.

No abstract.

35. Remarks on Two Convective-Powered Mechanisms of Cloud Electrification
 N. D'ANGELO
Ann. Geophys., submitted, 1986.

Some remarks are offered on two convection-powered mechanisms of cloud electrification, the Grenet-Vonnegut and the Wahlin mechanism.

36. A Comparison of the Plasma Wave Spectra From 100 Hz to 100 kHz for the Eight AMPTE Chemical Releases
 H. C. KOONS, R. R. ANDERSON, O. H. BAUER, D. A. GURNETT, G. HAERENDEL, R. H. HOLZWORTH, J. L. ROEDER and R. TREUMANN
J. Geophys. Res., submitted, 1986.

The AMPTE IRM spacecraft performed a series of eight chemical releases at high altitudes. There were two lithium releases in the solar wind, two lithium and two barium releases in the near-earth magnetotail, and two barium releases to simulate artificial comets, one in the solar wind and the other in the magnetosheath. A variety of plasma waves were observed in conjunction with each of the releases. The releases were performed essentially in comparable pairs. Although there were unique features associated with some of the individual releases, the comparable releases generally produced similar wave emissions. This paper will discuss the similarities and differences among the releases.

37. Computer Simulation of the Critical Ionization Velocity Phenomenon
 I. One-Dimensional Model
 S. MACHIDA, T. ABE, T. TERASAWA and C. K. GOERTZ
J. Geophys. Res., submitted.

We studied the Critical Ionization Velocity (CIV) process by first investigating a coupled system of equations describing the production of several ion species and electrons by impact ionization, their collisions with neutrals and the heating of electrons. Analytic relations derived from this were tested with the help of a particle simulation including collisional processes between neutrals and plasma particles. It was found that resistive heating of electrons plays an important role when the density of the neutrals is high, and that electron heating due to lower-hybrid waves is significant when the neutral density is low. In both cases, we verified the control of the plasma production rate by the ratio of the beam velocity to the critical velocity.

38. Electron Density Depletions in the Nightside Auroral Zone
 A. M. PERSOON, and D. A. GURNETT, W. K. PETERSON,
 J. H. WAITE, JR., J. L. BURCH, and J. L. GREEN
J. Geophys. Res., submitted, 1986.

Dynamics Explorer 1 plasma wave measurements are used to study regions of diminished electron density in the nightside auroral zone. Local electron densities are obtained from the electron plasma frequency cutoff of the whistler mode auroral hiss. Electron density profiles are highly variable through the nightside auroral zone. Sharply defined regions of low electron densities are a common feature of auroral zone crossings from the pre-dusk hours until the early morning hours at all radial distances up to at least $4.3 R_E$.

Electron densities in these regions are strongly depleted in relation to the adjacent polar cap and plasmaspheric densities, forming a low density cavity at $70^\circ \pm 5^\circ$ invariant latitude. Minimum densities in the auroral cavity frequently drop to 0.1 cm^{-3} and rarely exceed 3 cm^{-3} at radial distances of $2 R_E$ to $4.3 R_E$. Within the cavity, the electron density profile exhibits extreme variability, with variations of a factor of two or more on spatial scales of tens of kilometers. These fine scale variations are probably field-aligned density structures.

A comparison of the electron density depletions with simultaneously measured thermal and energetic particle measurements indicates a correspondence between low auroral plasma densities and upward-directed ion beams and conics and an energetic precipitating electron population. Low energy ($< 1 \text{ keV}$) upflowing H^+ ions are strongly correlated with the poleward edge of the auroral cavity. These correlations show that density depletions in the nightside auroral zone are directly associated with auroral acceleration processes.

39. Interpretation of Electrostatic Noise Observed by Voyager 1 in Titan's Wake

T. Z. MA, D. A. GURNETT and C. K. GOERTZ
J. Geophys. Res., submitted, 1986.

During the Voyager 1 spacecraft flyby of Titan on November 12, 1980, an intense band of low frequency electric field noise was observed during the inbound wake crossing. This analysis shows that the noise is generated by a beam-plasma interaction between the corotating magnetosphere of Saturn and newly created ions from the atmosphere of Titan. The analysis is based on plasma and wave measurements from Voyager 1 and reasonable assumptions. The results agree quite well with the observation. The analysis shows that the instability only occurs where the density of the corotational ions is comparable to the density of ions originating from Titan's atmosphere. The growth rate is high enough to generate the observed noise and the calculated and observed frequency ranges are in good agreement. The asymmetry between the intensities in the inbound and outbound wake are explained by a simple model for the trajectories of ions from Titan's atmosphere.

40. Observations of Nonlinear Wave Decay Processes in the Solar Wind by the AMPTE IRM Plasma Wave Experiment

H. C. KOONS, J. L. ROEDER, O. H. BAUER, G. HAERENDEL, R. TREUMANN, R. R. ANDERSON, D. A. GURNETT and R. H. HOLZWORTH
J. Geophys. Res., submitted, 1986.

Nonlinear wave decay processes have been detected in the solar wind by the plasma wave experiment aboard the AMPTE-IRM spacecraft. The main process is the generation of ultra-low-frequency ion-acoustic waves from the decay of Langmuir waves near the electron plasma frequency. This enhancement is most likely due to the generation of electromagnetic waves from the coalescence of two Langmuir waves. These processes occur within the electron foreshock in front of the earth's bow shock.

41. Electron Number Density From the AMPTE/IRM Plasma Wave Experiment During Solar Wind Lithium Releases

R. R. Anderson, D. A. Gurnett, B. Hausler, H. C. Koons, R. H. Holzworth, R. A. Treumann, O. H. Bauer, G. Haerendel, H. Luhr, L. J. Woolliscroft, and M. P. Gough
J. Geophys. Res., submitted, 1986.

In September 1984 the AMPTE project carried out two active chemical release experiments in space in which substantial amounts of lithium were injected into the solar wind in front of the Earth's bow shock and subsequently photoionized. The plasma wave instruments on the AMPTE/IRM (Ion Release Module) were used to monitor the solar wind environment throughout the release period and to detect the electrostatic and electromagnetic fields associated with the injections of the

ions into the solar wind. Plasma wave emissions at the upper hybrid resonance frequency or the electron plasma frequency were observed and subsequently used to determine the electron number density near the middle of the release as a function of time. These data provided valuable information on the degree of ionization, on the ionization rate, and on the ion density profile as a function of position inside the diamagnetic cavity that was formed during each release and in the perturbed region of space outside the cavity. The diamagnetic cavity lasted for about 11.5 and 7 seconds for the September 9 and 20 releases, respectively. For each of these releases the observed electron number density as a function of time after the release increased abruptly at the onset of the release and then was proportional to about t^{-2} until the spacecraft approached the edge of the cavity and the number density again increased for a short period of time. Outside the cavity the number density again fell toward the ambient solar wind number density but was quite irregular. Analysis of the high frequency receiver data showed that at 1 second into each Lithium release the electron number density was about $2.4 \times 10^4 \text{ cm}^{-3}$. In addition to determining the electron number density at the spacecraft the plasma wave data also provided information on number density remote from the IRM by observing the shadowing of electromagnetic radiation.

42. An Explanation for Triggered Auroral Kilometric Radiation, The Auroral Plasma Cavity, and Discrete Auroral Arcs
W. CALVERT
Geophys. Res. Lett., submitted, 1986.

An explanation is proposed for the external triggering of the auroral kilometric radiation (AKR) by solar radio bursts; for the development of the auroral plasma cavity which seems to accompany the AKR, and also for the formation of discrete auroral arcs--all based upon the generation of AKR by radio lasing, the consequent pitch-angle scattering of energetic electrons into the loss cone, and the subsequent precipitation of those electrons into the ionosphere.

43. Plasma Wave Turbulence Produced by the Shuttle: Results from the PDP Free Flight
D. A. GURNETT, W. S. KURTH, J. T. STEINBERG and S. D. SHAWHAN
Science, submitted, 1986.

During the Spacelab 2 mission, a spacecraft called the Plasma Diagnostics Package (PDP) was released from the shuttle to investigate plasma interactions near the shuttle. The plasma wave instrument on the PDP shows that a region of intense electrostatic turbulence exists around the shuttle at frequencies up to 10^4 Hz . This turbulence is closely associated with neutral gas releases from the shuttle and is most intense in the region downstream of the shuttle. Antenna pattern effects show that the turbulence has wavelengths less than 1 meter. Preliminary indications are that the noise is caused by an ion beam produced by charge exchange reactions in the neutral gas cloud around the shuttle.

44. Micron-Sized Particle Impacts Detected Near Uranus by the Voyager 2 Plasma Wave Instrument

D. A. GURNETT, W. S. KURTH, F. L. SCARF, J. A. BURNS, J. N. CUZZI and E. GRUN

J. Geophys. Res., submitted, 1986.

During the Voyager 2 flyby of Uranus, the plasma wave and radio astronomy instruments detected a region of impulsive noise near the equatorial plane just inside the orbit of Miranda, at a radial distance of $4.51 R_U$. This noise is believed to be caused by micron-sized particles hitting the spacecraft. Analysis of various coupling mechanisms shows that when a dust particle hits the spacecraft at a high velocity, the particle is instantly vaporized and ionized, thereby releasing a cloud of charged particles, some of which are collected by the antenna. The resulting voltage pulse is detected by the plasma wave instrument. Based on reasonable assumptions about the charge yield and collection efficiency of the antenna, the number density and mass of the particles can be estimated from the rate and amplitude of the voltage pulses. The analysis shows that the maximum number density of the particles is about $1.6 \times 10^{-3} \text{ m}^{-3}$, and the thickness of the impact region, based on a Gaussian fit, is 3480 km. The maximum number density occurs slightly after the ring plane crossing at a distance of about 280 km from the equatorial plane. The mass threshold for detecting the particles is estimated to be about $4.5 \times 10^{-10} \text{ gm}$, and the rms mass of the particles is about $2.6 \times 10^{-9} \text{ gm}$. For a density of a few gm cm^{-3} , the particles have radii on the order of a few microns. Possible sources for these particles include the rings, the small satellite 1985U1 discovered outside the ring system, or other unseen small bodies that lie between synchronous orbit ($3.15 R_U$) and $4.51 R_U$. If the particles are charged, electromagnetic forces produced by the rotating tilted dipole of Uranus may play a role in their transport and diffusion.